

**SIGNAL GENERATION POWER MANAGEMENT CONTROL SYSTEM FOR
PORTABLE COMMUNICATIONS DEVICE AND METHOD OF USING SAME**

TECHNICAL FIELD

5 This invention relates in general to power management and more particularly to power management in signal generation devices such as digital-to-analog converters (DAC), filters, buffer stages and amplifiers.

BACKGROUND

10 The use of digital-to-analog converter technology is well known and widely used to convert information from a stream of digital information such as voice or data into an analog signal. Once in the analog domain, signals can either be applied to any type of filter, mixer or speaker so that the analog signals can be heard and/or interpreted by a machine or the human ear or they may be mixed with another analog
15 signal and transmitted.

 Prior art signal generation topologies such as used with a DAC often were designed for situations to provide the best possible analog information for a given digital signal. This "over design" results both in a greater degree of circuit design area and an excessive current drain on a portable device that might use the DAC. In many
20 instances, the DAC may be interpreting digital information having a very low bit resolution while still operating as if the incoming digital information uses a digital protocol having a high bit resolution.

 Moreover, many digital protocols do not require low noise or low intermodulation distortion products, yet the DAC and other signal processing
25 components still process all incoming digital information in the same fashion. This often requires a greater degree of mathematical computation, processing, higher signal drive capability, higher clock speed and an overall greater current demand on a portable device using these components. In many instances, the DAC has been required to operate in this manner to meet published Telecommunications Industry
30 Association (TIA) communications standards where a high-quality analog output signal is required to be produced from a high-resolution digital signal. Although the

best digital-to-analog matching is not always required, the DAC and other processing components are operationally fixed for best case digital signaling conditions in order to produce the highest quality analog output. This approach becomes costly since the analog output from the DAC cannot be dynamically changed based on the type of digital signal received and the quality of analog output that is required.

Thus, the need exists to provide an adaptive system and method used with a DAC and other signaling processing components to dynamically control their dynamic range, output drive capability, signal amplitude swing and spectral content. The adaptive system should allow the signal processing requirements of these devices to be dynamically varied. This will enable the most efficient use of power in a portable communications device in order to best accommodate the type of digital information received and the quality of analog output required for a given digital input. This will enable the DAC and signaling processing components to conserve power when a high-quality analog output is not required, thereby allowing a portable communications device to dynamically manage its power consumption.

SUMMARY OF THE INVENTION

Briefly, according to the invention, there is provided a dynamic power management system for a portable communications device typically used with a DAC or similar digital signal processing components. The invention allows a bias controller located within a digital signal processor (DSP) to adjust bias current and related system components such as a DAC, analog filter, mixer power amplifier and related signal generation components to meet minimal analog signal requirements and to minimize current drain when used in a portable communications device. The DSP bias controller controls supply bias based on the incoming multiple access digital protocol (MA), signal amplitude swing and bandwidth for adjusting supply bias to achieve the appropriate noise figure and distortion requirements. The bias controller may also control a reference capacitance in the DAC, signal generation or processing components for adjusting slew rate.

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BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention, which are believed to be novel, are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by reference to the following
5 description, taken in conjunction with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIG. 1 is a block diagram showing the power management system of the present invention as used with a digital-to-analog converter (DAC) and other signal processing components controlled by a digital signal processor (DSP).

10 FIG. 2 is a flow chart diagram showing the power management when used with the DAC according to the preferred method of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

While the specification concludes with claims defining the features of the
15 invention that are regarded as novel, it is believed that the invention will be better understood from a consideration of the following description in conjunction with the drawing figures, in which like reference numerals are carried forward.

Referring now to FIG. 1, a block diagram of the digital-to-analog converter (DAC) power control system 100 includes a digital signal processor (DSP) 101 that is
20 used for processing a digital source input 101. The digital source input 101 may typically be a vocoder or the like that produces both voice data and control data used to convey both voice communications, handshaking and control information over the transmitter or receiver sections of a digital communications system. As will become evident to those skilled in the art, the invention may apply to the digital audio section
25 of any type of portable communications device such as a cellular telephone, two-way radio or compact disc (CD) player. The DSP 101 processes or formats the digital signal in a predetermined manner so as to produce a digitally modulated bit stream. The digital bit stream is applied to a DAC 103 which converts the digital bit stream into an analog modulated output signal.

30 The analog output modulated signal is then typically applied to a DAC filter 105 which can further shape or manipulate the frequency response of the analog signal.

In the transmit mode, this filtered signal is applied to mixer 107. After mixing with a local oscillator (LO) signal, an intermediate frequency (IF) signal is produced by mixer 107 that is applied to a post mixer amplifier 109. The IF signal is a radio frequency (RF) signal that can be transmitted using a two-way portable communications device
5 such as a cellular telephone or two-way radio or the like. The post mixer amplifier 109 is then used to increase the amplitude of the IF signal that may be at radio frequency (RF) such that it can be applied to power amplifier 111 and transmitted using antenna 113. As seen in FIG. 1, in the receive mode the filtered signal from the DAC filter 105 is applied to a pre-amplifier 108, output audio amplifier 110 and speaker 112. As
10 will be evident to those skilled in the art, the invention may also be used in connection with an portable analog audio output system such as a compact disc (CD) player (not shown) in order to achieve the most efficiency and least amount of current drain.

In accordance with the preferred embodiment of the invention, the DAC power control system 100 includes a power management controller 115 within the DSP 101
15 that works to control processing components in the transmitter and receiver of the communications device. Since the DSP 101 determines the amplitude, frequency and protocol of the incoming digital signal that is processed, the power management controller 115 can work to adjust the bias current used by the DAC 103, DAC filter 105. In the transmitter section, the bias controller 115 controls the post mixer
20 amplifier 109 and power amplifier 111, depending on the quality of analog signals required from the DAC 103. The DAC 103, DAC filter 105, mixer 107, post mixer amplifier 109, power amplifier 111, preamp 108 and output amplifier 110, include a separate supply bias control which is used to precisely control the amount of current drain of the device. Thus, the power management controller 115 controls the pre-
25 amplifier 108 and output audio amplifier 110 that are used to provide audio output. The power management controller 115 works to determine the minimum required supply bias current for the specific multiple access digital protocol (MA) determined by the DSP 101.

This determination is based upon the minimum required noise figure and
30 distortion of the analog output signal from the DAC 103. Moreover, the power management controller 115 can also control a reference capacitance value within the a

DAC 103, DAC filter 105, mixer 107, post mixer amplifier 109, power amplifier 111 as well as a transmitter section that includes pre-amplifier 108, and output audio amplifier 110. This reference capacitance value is used for adjusting slew rate of these components to meet distortion requirements. As will be recognized by those skilled in the art, slew rate is the term used to describe how quickly the potential on a circuit node must change with respect to time. As a result, the slew rate is the rate of change of a voltage as measured in volts per second (V/S). Typically the slew rate is not limited in digital circuit design since it is desirous to have the digital circuit slew quickly enough to preserve the original waveform shape during transmission.

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10 However, a factor which does slow this rate is capacitance. A reference capacitance used by the portable communications device can be controlled in order to maintain some predefined slew rate and distortion level. The current in the reference capacitance operates using the equation:

15 $I = C (dv/dt)$ where I is current in amps, C is capacitance in farads, dv is the change in voltage and dt is the change in time.

Hence, the current used by the reference capacitance will increase with either an increase in reference capacitance value or with an increase in voltage per the same operating time period. Since the invention operates to vary the value of this reference capacitance, the current drain of the capacitance can be lessened for the same change in voltage over time. Ultimately, this enables the power used by the DAC 103, DAC filter 105, post mixer amplifier 109, and power amplifier 111 in the transmitter, the pre-amplifier 108 and output amplifier 110 in the receiver, including other associated components, to be dynamically managed based on predetermined desired analog signal parameters. This ensures that only a minimal current is used by the power management system to charge the reference capacitance in order to control current drain in the portable communications device.

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With regard to FIG. 2, a flow chart diagram showing the preferred method of using the DAC power management control system 200 includes first initializing 201 the device using the invention where the bias used by the components in the device is

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set to a predetermined value. A digital multiple access protocol (MA) is then determined 203, and a digitally modulated bit stream is generated 205 typically from a DSP. By using a DAC, the digitally modulated bit stream is scaled 207 such that the digital bit stream is converted into an analog signal. As is known in the art, the digital
5 bit stream may be scaled for condition, power, deviation, MA or the particular type of receiver architecture requirements.

The quantizer within the DAC can then be adjusted 209 such that specific scale factor, i.e., a minimum bias needed to operate the DAC and other processing components, can be selected based upon the MA, signal amplitude swing and signal
10 bandwidth and desired noise figure or inter-modulation distortion (IMD) requirements. Moreover, a reference capacitance with the DAC or other processing components can be adjusted to control slew rate and the most optimal power efficiency. This adjustment is important since slew rate and noise figures are inverse relations. With an increase in capacitance there is a proportional decrease in slew rate and thermal noise.
15 This balance between capacitance, slew rate and noise is taken into account when attempting to adjust for maximum power efficiency of the portable communications device.

In order to ensure that only the lowest bias current is used to satisfy minimal desired analog signal requirements, a DAC buffer, DAC filter, mixer or power
20 amplifiers can further be adjusted 211 to dynamically control power used by a communications device using the method of the instant invention. Once these adjustments have been made, the method enables a continual dynamic power adjustment using a loop, whereby these steps are repeated and incoming digital information can continually be processed by a DSP. This enables the power
25 management control system 200 to continually reevaluate the incoming digital bit stream to maintain a minimum current drain based on required analog signal requirements.

Accordingly, the present invention is a dynamic power management system typically used with a DAC or similar digital signal processing components. The
30 invention allows a bias controller located within a DSP to adjust supply bias current of system components such as a DAC, analog filter, mixer and power amplifier to meet

minimal analog signal requirements and minimize current drain in a portable communications device. The DSP controls bias based on the MA, noise figure, distortion and may also control a reference capacitance used to control slew rate in the DAC and other signal generation components.

- 5 While the preferred embodiments of the invention have been illustrated and described, it will be clear that the invention is not so limited. Numerous modifications, changes, variations, substitutions and equivalents will occur to those skilled in the art without departing from the spirit and scope of the present invention as defined by the appended claims.